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A MODIFIED CONCEPT OF CONSCIOUSNESS[1]

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The long-standing assumption in the neurosciences that the subjective phenomena of conscious experiences do not exert any causal influence on the sequence of events in the physical brain process is directly challenged in this current view of the nature of mind and the mind–brain relationship. A theory of mind is suggested in which consciousness, interpreted to be a direct emergent property of cerebral activity, is conceived to be an integral component of the brain process that functions as an essential constituent of the action and exerts a directive holistic form of control over the flow pattern of cerebral excitation.

In studies involving surgical section of the cerebral commissures, we have been confronted repeatedly in recent years with questions concerning the quality and distribution of conscious awareness in the bisected brain, particularly in work with human patients (Sperry, 1968a, 1968b; Sperry, Gazzaniga, & Bogen, 1969). In the surgically separated state, the two hemispheres appear to be independently and often simultaneously conscious, each quite oblivious of the mental experiences of the opposite hemisphere and also of the incompleteness of its own awareness. Many problems are raised in regard to the seeming unity of conscious experience in both the normal and bisected condition and the relation of conscious unity to the neural process. How should we conceive the unifying role of the corpus callosum and the nature of the information it carries between the two domains of consciousness? Do the conscious qualities extend from grey matter into the corpus callosum? What is the nature of the interface between the conscious and unconscious processes?

One of the things to come out of these and related concerns, as a somewhat corollary development, has been a modified concept of the nature of mind and its relation to brain activity. This revised view has continued to gain increasing support in the author's thinking over the past 5 years (Sperry, 1966, 1969a, 1969b) and is now favored over other alternatives. We deal here, of course, with the Number 1 problem in brain research, for which the evidence at hand still falls far short of providing any full or final answer. Nevertheless, the supreme importance of the problem for all kinds of human value, as well as scientific matters, prompts us to search ahead of the evidence from time to time as science advances, for any possible new insight. Even a partial solution that would enable us to decide between very broad and general alternatives—like whether consciousness is cosmic or individual, mortal or immortal, in possession of free will or subject to causal determinism, and the like—could have profound and far reaching ideological implications. In any search for meaning, identity, ultimate goals and values, or new ideologies, the nature of mind and its relation to physical reality becomes central and basic.

Most behavioral scientists today, brain researchers in particular, have little use for consciousness. From the objective experimental standpoint, it is difficult to see any place in the material brain process for the likes of conscious experience. Most investigators of cerebral function will violently resist any suggestion that the causal sequence of electro-physico-chemical events in the brain, that they work with and are trying to analyze, could in any way be influenced by conscious or mental forces. It is the

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working man's faith in the neurosciences—that goes back to near the turn of the century—that a complete objective explanation of brain function is possible in principle without any reference to the subjective mental phenomena. Whatever the stuff of consciousness, it is generally agreed in neuroscience that it does not interact back causally on the brain's electrophysiology or its biochemistry.

The current interpretation of consciousness takes issue with this prevailing view of twentieth century science. In the present scheme the author postulates that the conscious phenomena of subjective experience do interact on the brain process exerting an active causal influence. In this view consciousness is conceived to have a directive role in determining the flow pattern of cerebral excitation. It has long been the custom in brain research to dispense with consciousness as just an "inner aspect" of the brain process, or as some kind of parallel passive "epiphenomenon" or "paraphenomenon" or other impotent by-product, or even to regard it as merely an artifact of semantics, a pseudoproblem (Boring, 1942; Eccles, 1966; Hook, 1961).

The present interpretation by contrast would make consciousness an integral part of the brain process itself and an essential constituent of the action. Consciousness in the present scheme is put to work. It is given a use and a reason for being, and for having been evolved. On these terms subjective mental phenomena can no longer be written off and ignored in objective explanations and models of cerebral function, and mind and consciousness become reinstated into the domain of science from which they have been largely excluded since the advent of behaviorism and dialectic materialism. Without going through all the details, an attempt is made in the following to briefly outline the salient features of the hypothesis and some of the reasoning behind the foregoing statements.

First, conscious awareness, in the present view, is interpreted to be a dynamic emergent property of cerebral excitation. As such, conscious experience becomes inseparably tied to the material brain process with all its structural and physiological constraints. At the same time the conscious properties of brain excitation are conceived to be something distinct and special in their own right. They are "different from and more than" the collected sum of the neurophysico-chemical events out of which they are built.

Compared to the elemental physiological and molecular properties, the conscious properties of the brain process are more molar and holistic in nature. They encompass and transcend the details of nerve impulse traffic in the cerebral networks in the same way that the properties of the organism transcend the properties of its cells, or the properties of the molecule transcend the properties of its atomic components, and so on. Just as the holistic properties of the organism have causal effects that determine the course and fate of its constituent cells and molecules, so in the same way, the conscious properties of cerebral activity are conceived to have analogous causal effects in brain function that control subset events in the flow pattern of neural excitation. In this holistic sense the present proposal may be said to place mind over matter, but not as any disembodied or supernatural agent.

When it is inferred that conscious forces shape the flow pattern of cerebral excitation, it is not meant to imply that the properties of consciousness intervene, interfere, or in any way disrupt the physiology of brain cell activation. The accepted biophysical laws for the generation and transmission of nerve impulses, for example, are in no way violated. The electrophysiologist, in other words, does not need to worry about any of this, provided that he restricts himself to analytic neurophysiology. He does need to be concerned, however, if he wishes to follow a sensory input to conscious levels and to explain how a sensation or a percept is produced, or how the subsequent volitional response is generated.

Although the mental properties in brain activity, as here conceived, do not directly intervene in neuronal physiology, they do *super*vene. This comes about as a result of higher level cerebral interactions that

involve integration between large processes and whole patterns of activity. In the dynamics of these higher level interactions, the more molar conscious properties are seen to supersede the more elemental physiochemical forces, just as the properties of the molecule supersede nuclear forces in chemical interactions.

To put this another way—the individual nerve impulses and associated elemental excitatory events are obliged to operate within larger circuit-system configurations of which they as individuals are only a part. These larger functional entities have their own dynamics in cerebral activity with their own qualities and properties. They interact causally with one another at their own level as entities. It is the emergent dynamic properties of certain of these higher specialized cerebral processes that are interpreted to be the substance of consciousness. It would be helpful if one could illustrate the foregoing with a few fluoroscopy-like film sequences of some of the higher cerebral activity patterns in action. As yet, however, the instrumentation in brain research remains entirely inadequate to record the pattern dynamics of brain activity. About the only instrument known at present by which one brain can plug into and read out directly the conscious experience of another brain, is the corpus callosum.

The subjective mental phenomena are conceived to influence and to govern the flow of nerve impulse traffic by virtue of their encompassing emergent properties. Individual nerve impulses and other excitatory components of a cerebral activity pattern are simply carried along or shunted this way and that by the prevailing overall dynamics of the whole active process (in principle—just as drops of water are carried along by a local eddy in a stream or the way the molecules and atoms of a wheel are carried along when it rolls down hill, regardless of whether the individual molecules and atoms happen to like it or not). Obviously, it also works the other way around, that is, the conscious properties of cerebral patterns are directly dependent on the action of the component neural elements. Thus, a mutual interdependence is recognized between the sustaining physico-chemical processes and the enveloping conscious qualities. The neurophysiology, in other words, controls the mental effects, and the mental properties in turn control the neurophysiology. One should remember in this connection, however, that the conscious phenomena are in a position of higher command, as it were, located at the top of the organizational hierarchy.

The present hypothesis represents a midway compromise between older extremes of mentalism on the one hand and materialism on the other. The present is mentalistic in accepting the existence of potent mental forces that transcend the material elements in cerebral function. It is materialistic in denying that these mental forces can exist apart from the brain process of which they are a direct property. This "emergent interactionism," or "idealistic materialism" as some would label the present compromise, permits proponents of both extremes to retain some of their more important concepts.

Whereas the older interpretations of consciousness as inner aspect, epiphenomenon, or semantic pseudoproblem have remained largely sterile, conceptually and experimentally (e.g., there is no place to go from an epiphenomenon), the emergent interaction scheme is by contrast potentially fruitful. It suggests new problems, possible approaches, and new leads to follow in working out the nature of the mental properties, their interactions, and their relations to the sustaining neurophysiology. For example, it follows directly from the foregoing that the brain process must be able to detect and to react to the pattern properties of its own excitation. It must detect the overall qualities of different kinds and different species of cerebral process and respond to these as entities rather than to their individual cellular components. There exists considerable indirect evidence, particularly from observations on perceptual and cognitive phenomena, that the brain does in fact do exactly this. One may include here the extensive evidence on perception collected during the 1920s and 1930s by the Gestalt school of psychology (Koffka, 1935; Kohler, 1929). The present view rests largely on an ex-

tension of some of the same holistic principles extrapolated now to cerebral physiology. Earlier experiments in which the author's findings had seemed to undermine Gestalt field theory, along with the related concept of psychoneural isomorphism (Sperry & Miner, 1955; Sperry, Miner, & Myers, 1955), do not apply to the present interpretation. The conscious properties are here conceived quite differently in terms of operational effects of specialized neural circuitry (Sperry, 1952) rather than in terms of isomorphic correspondence based on electric field effects or volume conduction.

Among other implications of the current view for brain research is the conclusion that a full explanation of the brain process at the conscious level will not be possible solely in terms of the biochemical and physiological data such as we are now perforce engaged in gathering. Important as these analytic data are for understanding cerebral activity, they must fall short of providing an account of mental phenomena like sensations, percepts, ideas, images, illusions, feelings, etc. For a full explanation of these gnostic functions, we are going to need, in addition, a further description and account of the higher order pattern activity in the cerebral process, the emergent properties of which are conceived to constitute the qualities of consciousness.

The foregoing points out also the specific problem of determining the nature of the unifying forces that cause a pattern of excitatory events to function as an entity in brain dynamics. It emphasizes further the need for new technology that will enable us to record the pattern aspects of cerebral function which at present can only be extrapolated from indirect or highly particulate sampling procedures.

To determine precisely how the more elemental physiological aspects of brain activity are used to build the emergent qualities of awareness becomes the central challenge for the future. At present even the general principles by which cerebral circuits produce conscious effects remain obscure. Very possibly these will become understandable, not in terms of isolated circuit principles, but only in terms of advances in cerebral design superimposed on the background of an already elaborately evolved central nervous system. There is reason to think that the critical organizational features of the neural circuitry for generating conscious awareness are mainly genetic or inherent and are activated through the brain-stem arousal system, and once activated, become exquisitely responsive to changing sensory as well as centrally generated input.

This present interpretation implies some revision in traditional stimulus-response concepts of central nervous control. Any scheme, regardless of its complexity, in which sensory impulses are conceived to be routed through a central network system into a motor response becomes misleading. The present view suggests the presence of ongoing central processes specifically organized for conscious awareness around the different sensory modalities. These central mechanisms have their own intrinsic organization and special dynamics that in large part are determined centrally and autonomously. The sensory input becomes incorporated into the central process, altering the dynamics of the system and thereby its conscious properties. The initial train of sensory inflow is largely absorbed and transformed within the higher level central mechanism, and only indirectly through its perturbation of the holistic properties of the central process does the sensory input influence awareness or the volitional motor response. The present view places greater emphasis on the central processes and their specialized organizational features that create out of neural excitation the higher order phenomena of mental experience.

Returning to the primary thesis, it may be taken to imply something like the following: As we look around the room at different objects in various shapes, shades, and colors, the colors and shapes we experience, along with any associated smells and sounds, are not really out where they seem to be. They are not part of the physical qualities of the outside objects, but instead, like hallucinations or the sensations from an amputated phantom limb, they are entirely inside the brain itself. The perceived colors and sounds, etc., exist within the brain not as

epiphenomena, but as real properties of the brain process. When the brain adjusts to these perceived colors and sounds, the adjustment is made not merely to an array of neural excitations correlated with the colors and sounds but rather to the colors and sounds themselves. Many uncertainties obviously remain and the foregoing is only proposed on a tentative and speculative basis for its consideration alongside the alternative theories for explaining mind and consciousness available to date.

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